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A SURVEY AND RESOURCE MATERIALS ON THE USE OF OXYGEN SUPPLEMENTATION IN FISH CULTURE

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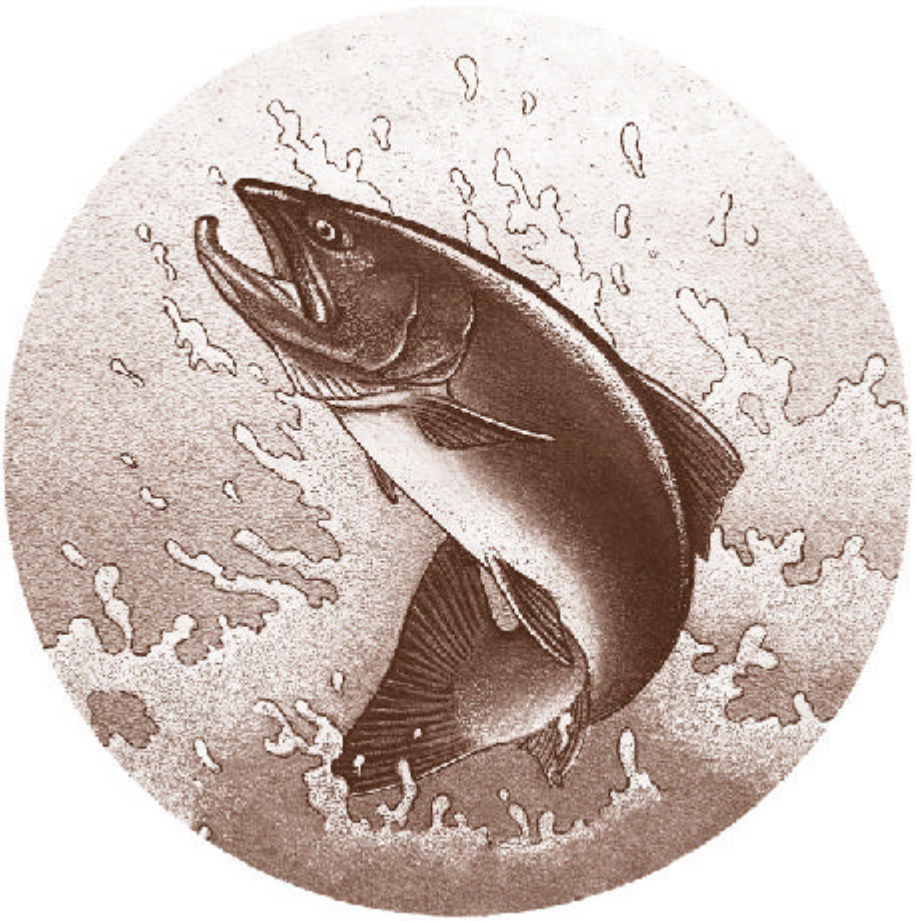

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A SURVEY AND RESOURCE MATERIALS ON THE USE OF OXYGEN SUPPLEMENTATION IN FISH CULTURE

by

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Fish Factory

and

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Aquatic Biotics

Prepared For

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September 1988

TABLE OF CONTENTS

SECTION I

INTRODUCTION

Oxygen supplementation is the process by which naturally occurring dissolved oxygen (DO) is supplemented with enriched oxygen to restore or enhance DO levels in water. In aquaculture this is usually done with relatively pure oxygen and the result has significant potential to improve fish health, aid hatchery economic considerations, or both. For example, oxygen supplementation can preclude both hypoxia and gas bubble disease, as well as allow more fish to be reared in the same space or water or both. However, the concepts and technology in oxygen supplementation are evolving rapidly and direct communication with the user groups would foster technology transfer and improve implementation. Therefore we undertook and now report a survey of organizations that either currently use or plan to use oxygen supplementation. Additionally we included various pertinent material, including literature sources, lists of consultants and equipment manufacturers and some current research in oxygen supplementation.

The use of modern oxygen absorption equipment in aquaculture is of particular interest because of its unique ability to economically saturate or supersaturate water with dissolved oxygen (DO). Supersaturated DO concentrations in the absorber effluent significantly reduces the volume of water that must be treated to satisfy a given oxygen demand. Unlike air contact systems, some oxygen absorbers also have the capacity of reducing dissolved nitrogen to or below saturation for the purposes of controlling gas bubble gas bubble disease. The extent of nitrogen stripping or oxygen

absorption can be easily regulated by adjusting oxygen flow rates and/or system operating pressures.

Methods

Our survey was conducted by developing a questionnaire and mailing it to over 3000 individuals or agencies whose addresses were supplied by the American Fisheries Society and Mr. Larry Vischer of the U.S. Fish and Wildlife Service. Detailed operational characteristics of the individual oxygen supplementation systems were requested. In some cases, these data were considered proprietary information, but most respondents shared the available information when approached with a specific question or situation.

Results and Discussion

Approximately 780 replies were received from individuals mainly in North America and Europe. The resulting information is listed elsewhere in this report. Forty fish culture facilities are already equipped with supplemental oxygen. (Canada = 6; Israel = 2; Norway = 1; United States = 31; and West Germany = 1.) Many of these have been operating with supplemental oxygen for several years and the respondents often volunteered numerous comments regarding their favorable results. We also discovered that another 35 facilities (in the design or construction phases) will soon be equipped with supplemental oxygen. (Canada = 2; United States = 32; and West Germany = 1.) The results of this survey lends considerable credibility to the thesis that supplemental oxygen is coming of age in fish aquaculture.

Readers are encouraged to communicate directly with the persons who already use supplemental oxygen or related equipment. To this end we included the names, addresses, and telephone numbers of users, researchers, and consultants active in oxygen supplementation and the manufacturers of oxygen supplementation equipment.

Acknowledgements

This report was funded in part by the Bonneville Power Administration, U.S. Department of Energy and the Bioengineering Section of the American Fisheries Society. Additional copies of this report can be obtained from **Bonneville Power Administration (PJS), P.O. Box 3621, Portland, OR 97208, USA.**

SECTION II

LITERATURE SOURCES

BIOLOGICAL EFFECTS OF SUPPLEMENTAL OXYGEN

Oxygen Toxicity

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BIOLOGICAL EFFECTS OF INCREASED INTENSITY

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SECTION III

LIST OF OXYGEN SUPPLEMENTATION SYSTEMS IN OPERATION

Companies and individuals using oxygen supplementation systems are presented in this section. They are sorted by country and user name.

The following codes are used:

Type of Oxygen Absorber System

a	not used	e	pressurized packed column
b	packed column	f	aeration cones
c	spray column	g	oxygen injection
d	other	h	u-tube

Source of Oxygen

1 '	liquid oxygen
c	compressed gas
P	pressure-swing absorption

Interests

a	Economics of Supplemental Oxygen
b	Use of Supplemental Oxygen Systems
c	Design/Engineering of Supplemental Oxygen Systems
d	Physiological/Biological Effects of Supplemental Oxygen
e	Oxygen Toxicity/Gas Bubble Trauma due to High Oxygen Concentrations

CANADA

Michael Bohm 705-663-2311
North Bay Fish Culture Station
RR # 1
Redbridge, ON POH 2A0
CANADA

Type of oxygen absorber system	g
Source of oxygen	c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abe

Murray Hi ll 902-485-5056
Aquaculture and Inland Division
P.O. Box 700
Picton, NS BOK 1HO
CANADA

Type of oxygen absorber system	g
Source of oxygen	c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	ac

Gintas Kamaitis 416-831-0697
Coolwater Farms Limited
591 Liverpool Rd.
Pickering, ON L1W 1Rl
CANADA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	50
Absorption efficiency (%)	90
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	ab

Robert Kidd 306-332-5995
Fort Qu'Applle Fish Culture Station
Box 190
Fort Qu'Applle, SK SOG 1SO
CANADA

Type of oxygen absorber system	g
Source of oxygen	c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	d

Paul Lyon **902-566-0824**
Atlantic Veterinary College
550 University Ave
Charlottetown, PEI C1A 4P3
CANADA

Type of oxygen absorber system	**g**
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

Shirley Roach **506-633-5897**
Sea Farms Canada
Box 2030
St. John, NB E2L 3T5
CANADA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	**0.43**
Absorption efficiency (%)	**80-90**
Effluent DO (mg/l)	**8**
Effluent Nitrogen (%)	
Interest	abcde

I SRAEL

I. Bejerano 065-86317
Ministry of Agriculture
Laboratory for Research of Fish Diseases
BAMIDGEH, Editorial Office
NIR-DAVID 19150
ISRAEL

Type of oxygen absorber system	be
Source of oxygen	
Absorption rate (kg/hr)	**0.3-0.6**
Absorption efficiency (%)	**95**
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	bde

Sarah Maurice 04-988-137
Dagnoy - Hazorea Fish Hatchery
Kibbutz Harorea **30060**
ISRAEL

Type of oxygen absorber system	e
Source of oxygen	P
Absorption rate (kg/hr)	
Absorption efficiency (%>	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	bde

NORWAY

M. Smith **073-15374**
Maritech Aqua A/S
R & D Station
6560 Langoyneset
NORWAY

Type of oxygen absorber system	bf
Source of oxygen	P
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

USA

James Bates **914-692-6706**
Hudson River Striped Bass Hatchery
R.D. 2, Box 91; Goslen Turnpike
Middletown, NY 10940
USA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	10.5
Effluent Nitrogen (%)	

Interest	bce

Vernon Bennett 616-389-2211
Harrietta State Fish Hatchery
6801 W 30 Mile Road
Harrietta, MI 49638
USA

Type of oxygen absorber system	g
Source of oxygen	P
Absorption rate (kg/hr)	8
Absorption efficiency (%)	35-45
Effluent DO (mg/l)	13-15
Effluent Nitrogen (%)	97-99
Interest	cd

Irvin Brock 907-428-1347
Fort Richardson Hatchery
P.O. Box 5-337
Fort Richardson, AK 99505
USA

Type of oxygen absorber system	c
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	50
Effluent DO (mg/l)	
Effluent Nitrogen (%)	90
Interest	abcde

Robert Burr 206-393-7822
Cypress Salmon Inc.
3013 Mtn. View Ave North
Renton, WA 98056
USA

Type of oxygen absorber system	g
Source of oxygen	1c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

We use oxygen airlifts in netpens to increase DO caused by low tidal currents or toxic plankton blooms.

Ken Buss 814-466-6446
520 W. Main St.
Boalsburg, PA 16827
USA

Type of oxygen absorber system	f
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	90
Effluent DO (mg/l)	
Effluent Nitrogen (%)	100

Interest

Used aeration cones in silos for trout production from 1970 - 1974.

Joseph Buttner 716-395-5750
Dept Biological Sciences
SUNY Brochport
Brockport, NY 14420
USA

Type of oxygen absorber system	
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	

Interest abcde

David Cochran 404-276-3803
Blue Ridge Mountain Fisheries
Rt 1 Box 317
Talking Rock, GA
USA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	0.8
Absorption efficiency (%)	100
Effluent DO (mg/l)	100
Effluent Nitrogen (%)	

Interest abcde

Richard Colantuno 717-866-2461
Aqua-Life Inc
RD # 1 Box 57
Richland, PA 17087
USA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	60-90
Effluent DO (mg/l)	8-10
Effluent Nitrogen (%)	100

Interest	abcde
James Copeland Wolf Lake State Fish Hatchery 34270 C.R. 652 Mattawan, MI 49071 USA	616-668-3388
Type of oxygen absorber system	c
Source of oxygen	P
Absorption rate (kg/hr)	32
Absorption efficiency (%)	50
Effluent DO (mg/l)	
Effluent Nitrogen (%)	<l00
Interest	bc
Speros Doulos Saratoga National Fish Hatchery P.0. Box 665 Saratoga, Wyoming 82331 USA	307-326-5662
Type of oxygen absorber system	**eg**
Source of oxygen	lcp
Absorption rate (kg/hr)	
Absorption efficiency (%)	**91**
Effluent DO (mg/l)	
Effluent Nitrogen (%)	105
Interest	abd
John Driver Marquette State Fish Hatchery 488 Cherry Creek Marquette, MI 49855 USA	906-249-1611
Type of oxygen absorber system	c
Source of oxygen	P
Absorption rate (kg/hr)	16
Absorption efficiency (%)	43-76
Effluent DO (mg/l)	12-19
Effluent Nitrogen (%)	80-92
Interest	abcde
Benjamin Florence Maryland Dept of Natural Resources 580 Taylor Ave Annapollis, MD 21401 USA	302-974-3733

Type of oxygen absorber system	b
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

Johnny Foster 919-772-8548
AAS
308 Loop Rd
Garner, NC 27529
USA

Type of oxygen absorber system	g
Source of oxygen	c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcd

Sandy Harris 208-336-2110
J. R. Simplot Company
P.O. 27, One Capital Center
Boise, ID 83707
USA

Type of oxygen absorber system	gh
Source of oxygen	1p
Absorption rate (kg/hr)	2.4
Absorption efficiency (%)	80
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	bcd

Larry Harris 303-484-2836
Colorado Division of Wildlife
317 West Prospect
Fort Collins, CO 80526
USA

Type of oxygen absorber, system	b
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abd

Jeffrey Hinshaw 709-684-3562
2016 Fanning Bridge Road
Fletcher, NC 28732
USA

Type of oxygen absorber system	b
Source of oxygen	1
Absorption rate (kgjhr)	variable
Absorption efficiency (%)	60-85
Effluent DO (mg/l)	12-16
Effluent Nitrogen (%)	100
Interest	abcde

I am an extension aquaculture specialist advising the North Carolina trout industry on the potential for supplemental oxygen use. We are currently testing supplemental oxygen on six farms in North Carolina.

Chris Kohler 618-453-2890
SLU Fisheries Research Lab
Southern 1Ilnois University
Carbondale, IL 62901
USA

Type of oxygen absorber system	**gh**
Source of oxygen	lc
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

Randall Link 414-528-8825
Kettle Moraine Springs Hatchery
Route 1 Trout Spring Rd
Adell, WI 53001
USA

Type of oxygen absorber **system**	g
Source of oxygen	c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

Eric Loudenslager 707-822-6225
Humboldt State University
Salmon Fish Hatchery
Arcata, CA 95521
USA

Type of oxygen absorber system	g
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

David Marolf 319-927-3276
Manchester Trout Hatchery
RR # 2, Box 269
Manchester, IA 52057
USA

Type of oxygen absorber system	b
Source of oxygen	cp
Absorption rate (kg/hr)	
Absorption efficiency (%)	**50**
Effluent DO (mg/l)	10
Effluent Nitrogen (%)	101
Interest	abcde

Andy Moore 515-647-2406
Rathbun Fish Hatchery
Rt 2, Box 298
Moravia, IA 52571
USA

Type of oxygen absorber system	**eg**
Source of oxygen	P
Absorption rate (kg/hr)	
Absorption efficiency (%)	**60**
Effluent DO (mg/l)	
Effluent Nitrogen (%)	**<95**
Interest	abcde

Richard Noble **206-943-4676**
Salmon/trout Advisory Service
P.O. Bxo 6232
Olympia, WA 98502
USA .

Type of oxygen absorber system	g
Source of oxygen	p
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/1)	
Effluent Nitrogen (%)	**<82**
Interest	abcde

Tom Pruitt	**701-654-7451**
Garrison Dam National Fish Hatchery	
P.0. Box 918	
Riverdale, ND 58565	
USA	
Type of oxygen absorber system	b
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde
Andrew Rivinus	503-867-7311
Oregon Aquafoods, Inc	
2000 Marine Science Dr.	
Newport, OR 97365	
USA	
Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	3 - 20
Effluent Nitrogen (%)	
Interest	a
Gerry Rowan	503-381-2206
Anadromous Inc.	
P.O. Box 437	
Ft. Klamath, OR 97626	
USA	
Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	3-4
Absorption efficiency (%)	
Effluent DO (mg/l)	11-13
Effluent Nitrogen (%)	103-105
Interest	bcde
Jim Stark	**503-746-4484**
Oregon Aqua Foods	
88700 Marcola Rd	
Springfield, OR 97478	
USA	

Type of oxygen absorber system	b
Source of oxygen	1
Absorption rate (kg/hr)	5-75
Absorption efficiency (%)	50-80
Effluent DO (mg/l)	30-40
Effluent Nitrogen (%)	82-98
Interest	abc

Scott Stuewe 309-968-7531
Jake Wolf Memorial Fish Hatchery
P.O. Box 560
Manito, IL 61546
USA

Type of oxygen absorber system	g
Source of oxygen	1P
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	101-109
Interest	abcde

C. Turner 205-683-6550
Marion Fish Hatchery
Rt 3 Box 35
Marion, AL 36756
USA

Type of oxygen absorber system	g
Source of oxygen	C
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	bd

Joe Valentine 801-654-0284
1596 West North Temple
Salt Lake City, 84116
USA

Type of oxygen absorber system	g
Source of oxygen	1
Absorption rate (kg/hr)	5.3
Absorption efficiency (%)	
Effluent DO (mg/l)	9
Effluent Nitrogen (%)	112

Interest	abcde

Dallas Weaver **714-960-4171**
8152 Evelyn Cr.
Hunnington Beach, CA 92646
USA

Type of oxygen absorber system	be
Source of oxygen	1
Absorption rate (kg/hr)	1
Absorption efficiency (%)	**70-100**
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abce

Paul Willenborg 301-855-1297
Chalk Point Aquaculture Center
Hallowing Point Field Station
RR 2, Box 81
Prince Frederick, MD 20678
USA

Type of oxygen absorber system	be
Source of oxygen	1c
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	abcde

WEST GERMANY

Rainer Obermeier
Bezirk Oberpfalz
"eichwirtschaftlicher Beispielsbetrieb
Wollershof
D-8487 Stoerns tein
WEST GERMANY

Type of oxygen absorber system	
Source of oxygen	
Absorption rate (kg/hr)	
Absorption efficiency (%)	
Effluent DO (mg/l)	
Effluent Nitrogen (%)	
Interest	ade

SECTION IV

LIST OF OXYGEN SUPPLEMENTATION SYSTEMS IN THE DESIGN OR CONSTRUCTION PHASE

Companies and individuals designing or constructing oxygen supplementation systems are presented in this section. They are sorted by country and user name.

The following codes are used:

Type of Oxygen Absorber System

a	not used	e	pressurized packed column
b	packed column	f	aeration cones
c	spray column	g	oxygen injection
d	other	h	u-tube

Source of Oxygen

1	liquid oxygen
c	compressed gas
P	pressure-swing absorption

Interests

a	Economics of Supplemental Oxygen
b	Use of Supplemental Oxygen Systems
c	Design/Engineering of Supplemental Oxygen Systems
d	Physiological/Biological Effects of Supplemental Oxygen
e	Oxygen Toxicity/Gas Bubble Trauma due to High Oxygen Concentrations

CANADA

Frank Dalriel 604-753-0641
Malaspina College
900 - Fifth St.
Nanaimo, BC V9R 5S5
CANADA

Interest abcde

Gerald Thorn 604-653-9315
Saltspring Aquafarms
RR-l, C-24 Bulman Rd
Fulford Harbour, BC vos 1C0
CANADA

Interest abcde

USA

Indiana Dept of Natural Resources
2650 SR 44
Martinsville, IN
USA

Type of oxygen absorber system e

Interest abcde

James -Anderson 803-638-2866
Walhalla National Fish Hatchery
P.O. Box 9
Walhalla, SC 29691
USA

Interest

Alan Brandenburg 618-529-4100
Little Grassy Fish Hatchery
Rt 1, Box 429
Carbondale, IL 62901
USA

Interest bce

Robert Busch' 208-543-8217
Clear Springs Trout Co.
P.O. Box 712
Buhl, ID 83316
USA

Type of oxygen absorber system e
Source of oxygen 1
Absorptioa rate (kg/hr) 3.3
Absorption efficiency (%) 100
Effluent DO (mg/l>
Effluent Nitrogen (%) 100

Interest abcd

Tommie Crawford 913-238-2638
Milford Fish Hatchery
Rt 3, Box 304
Junction City, KS 66441
USA

Interest abcde

L. Currywoods 301-335-3011
Crane Aquaculture Facility
P.O. Box 1475
Baltimore, MD 21203
USA

Interest abcde

James Davis 408-845-7473
Texas Agricultural Extension Service
102 Nagle Hall
College Station, TX 77840-2258
USA
Type of oxygen absorber system fh

Interest acd

David Erickson 208-543-8217
Clear Springs Trout Co.
Box 712
Buhl, ID 83316
USA
Type of oxygen absorber system b

Interest abde

Larry Ferber 605-394-2397
Clechorn Springs Hatchery
SD Game, Fish and Parks
Route 8, Box 4800
Rapid City, SD 57702
. USA

Type of oxygen absorber system I3
Source of oxygen P

Interest	abcde
Mike Gafford Namakan West Fisheries P. 0. Box 2162 Los Banos, CA 93635 USA	209-826-6176
Interest	b
Frank Gisset Atlantic Salmon (Maine) Oquossoc Fish Hatchery Oquossoc, Maine 04904 USA	**207-872-0882**
Interest	abcde
Jim Gleim Nebraska Game & Park Commission Rt. 4, Box 270 North Platte, NE 69101 USA	**308-532-6200**
Type of oxygen absorber system	bc
Source of oxygen	P
Absorption rate (kg/hr)	
Absorption efficiency (%)	**60**
Effluent DO (mg/l)	**9.2**
Effluent Nitrogen (%)	**98**
Interest	ac
Josh Goldman Aqua Future 30 Main St Montague, MA 01351 USA	**613-36 7- 9543**
Type of oxygen absorber system	**gh**
Source of oxygen	1
Interest	abc
Jerry McClain Iron Rive National Fish Hatchery HCR, Box 44 Iron River, WI **54847** USA	715-372-8510
Interest	abcde
Reginal Harrell Horn Point Aquaculture Facility Box 775 Cambridge, MD 21673 USA	301-228-8200

Interest	abc

Pat Hutson 512-352-0572
Texas Parks and Wildlife
P.O. Box 947
San Marcos, TX 78667-0947
USA

Interest	cd

Jay Kidder 206-441-7500
R. W. Beck & Associates
2121 4 th Ave.
Seattle, WA 98121
USA

Type of oxygen absorber system	bceg
Source of oxygen	c
Interest	abcde

Potential use of supplemental oxygen at Medvelle Creek Hatchery for chinook expansion.

Don Livingston 602-744-9060
5133 W. Blackbird Dr.
Tucson, AZ 85741
USA

Type of oxygen absorber system	g
Interest	f

William Logan 303-493-4831
Keeton Fisheries Consultants
419 Canyon Ave, Suite 215
Fort Collins; CO 80521
USA

Type of oxygen absorber system	d
Source of oxygen	P
Interest	abcde

Using Michigan type columns for tilapia and bass

Gene McCarty 512-389-4651
Texas Parks and Wildlife
4200 Smith School Rd
Austin, TX 78744
USA

Interest	a c e

Dave Meuninck 219-255-4199
Twin Branch State Fish Hatchery
13200 Jefferson
Mishawaka, IN 46545
USA

Interest	bcd
Loren Moseley Black & Veatch P.O. Box 8405 Kansas City, MO 64114 USA	913-339-2648
Interest	acde
John Nightingale BIOS 84 University St., 8407 Seattle, WA 98101 USA	206-587-2457
Type of oxygen absorber system	e
Interest	bcd
Paul Scowden Ohio Division of Wildlife 8589 Horseshoe Road Ashley, OH 43003 USA	614-747-2525
Type of oxygen absorber system	g
Interest	b
Fritz Sniderman Silverking Oceanic Farms P.O. Box 2184 Santa Cruz, CA 95063 USA	408-335-3491
Interest	abcde
Roger Sorensen Arizona Game & Fish 2222 W. Greenway Road Phoenix, AZ 85023 USA	602-942-3000
Interest	c
Verl Stevens Kansas Dept of Wildlife & Parks Rt. 2, Box 54A Pratt, KS 67124 USA	316-672-5911
Type of oxygen absorber system	g
Source of oxygen	1
Interest	bc

The use of supplemental oxygen for raceway culture of channel catfish.

Mike Stratton **503-229-5006**
Oregon Dept. Fish & Wildlife
P.O. Box 59
Portland, OR 97207
USA

Interest abcde

Mike Stroup 601-769-1758
Sea Chick
1034 Jackson
Pascagoula, MS 39567
USA

Type of oxygen absorber system h
Source of oxygen 1
Absorption rate (kg/hr)
Absorption efficiency (%) **90**
Effluent DO (mg/l)
Effluent Nitrogen (%)

Interest

Scott Stuewe 309-968-7531
Jake Wolf Memorial Fish Hatchery
P.O. Box 560
Manito, IL 61546
USA

Interest c

Neal Ward 303-872-3170
Hotchkiss National Fish Hatchery
807-3150 Lans
Hotchkiss, CO 81414
USA

Interest abcde

Warren Yoder **906-341-5587**
Thompson State Fish Hatchery
RT 2, Box 2555
Manisteque, MI 49854
USA

Interest cde

WEST GERMANY

Joerg Wenz
Aqua-Tek
Schluterstr, 39
D-1000 Berlin 12
WEST GERMANY

Type of oxygen absorber system	e
Interest	d

SECTION V

RESPONSE OF PRIVATE CONSULTANTS IN OXYGEN SUPPLEMENTATION

Consultants and individuals active in the design of oxygen supplementation systems are presented in this section. They are sorted by country and company name. (This list is not intended to be an endorsement of individual consultants or companies, and is provided here as a convenience to the reader.)

CANADA

David Reid **416-238-0007**
UMA Engineering
5080 Commerce Blvd
Mississauga, ON
CANADA

Design of oxygen supplementation system for commercial trout farm with pressure swing adsorption unit.

NORWAY

Peter Christensen **02-506090**
A.S. Birger Christensen
Aslakveien 20, P.O. Box 114, Roea
0701 Oslo 7
NORWAY

Designed and installed 35 oxygen supplementation systems in Norway.

USA

Kris Orwict 916-678-5126
Aquatic Biotics
1245 Cunningham Dr.
Dixon, CA 95620
USA

Development of bio-criteria for supplemental oxygen systems

Jay Kidder 206-441-7500
R. W. Beck & Associates
2121 4 th Ave.
Seattle, WA 98121
USA

Potential use of supplemental oxygen at Medvelle Creek Hatchery for chinook expansion.

John Nightingale **206-587-2457**
BIOS
84 University St., #407
Seattle, WA 98101
USA

Loren Moseley 913-339-2648
Black & Veatch
P.O. Box 8405
Kansas City, MO 64114
USA

Vick Kaczynski 503-224-9190
CH2M Hill
2020 S.W. Fourth Avenue
Portland, OR 97201

Designed supplemental oxygen systems for:
Anadromous (Coos Bay, Oregon)
Oregon Aqua Foods (Springfield, Oregon)

Designing supplemental oxygen system for:
Page Springs State Hatchery (Arizona)

John Colt 916-678-5126
Fish Factory
P.O. Box 5000
Davis, CA 95617
USA

Designed supplemental oxygen systems for Page Spring State Fish Hatchery (Arizona)

Lincoln Cochran 217-753-0077
Fish Pro
1201 South 6th Street
Springfield, IL 62703
USA

Working on supplemental oxygen systems for:
Potomac Electric Power Company (Maryland),
San Marcos State Fish Hatchery (Texas),
Cleghorn Springs State Fish Hatchery (Rapid City, South Dakota)
Decorah State Fish Hatchery (Decorah, Iowa)

Wayne Daley 206-871-2727
Fish-Pro
3780 SE State Hwy 160
Port Orchard, WA 98366
USA

Designed supplemental oxygen system for Tonto State Fish Hatchery (Arizona)

William Logan 303-493-4831
Keeton Fisheries Consultants
419 Canyon Ave, Suite 215
Fort Collins, CO 80521
USA

Using Michigan type columns for tilapia and bass.

Jeffrey Hinshaw 709-684-3562
North Carolina State University
2016 Fanning Bridge Road
Fletcher, NC 28732
USA

I am an extension aquaculture specialist advising the North Carolina trout industry on the potential for supplemental oxygen use. We are currently testing supplemental oxygen on six farms in North Carolina.

Bob Piper 406-586-9520
Piper Technology
P.O. Box 3706
Bozeman, MT 59772
USA

Consultant to both commercial and governmental agencies.

Kevin Fitzsimmons **602-621-7962**
University of Arizona
Envir. Research Lab
2601 E. Airport Dr.
Tucson, AR 85706
USA

Will be getting pressure swing unit soon. Also working with Tilapia farmers using liquid oxygen system.

SECTION VI

RESPONSE OF MANUFACTURERS OF OXYGEN SUPPLEMENTATION EQUIPMENT

Manufacturers and individuals supplying equipment for oxygen supplementation systems are presented in this section. They are sorted by country, and company name. (This list is not intended to be an endorsement of any equipment or its manufacturer, and is provided here is a convenience to the reader.)

SWEDEN

Ewos, A B
P.O. Box 618
S-15127 Sodertalje
SWEDEN

Manufacture a type of pressurized supplemental oxygen column.

USA

Air Products 215-481-4911
Industrial Gas Division
Box 538
Allentown, PA 18105
USA

Manufacture oxygen absorber equipment.

Ed Clark **713-995-0808**
ATEC
8323 S.W. Fwy, Suite 800
Houston, TX 77074
USA

Manufacturer of the ATEC oxygen absorber units.

Ted Gregg 503-758-1555
EMA Marketing, Inc.
5065 Southwest Nash Avenue
Corvallis, OR 97333
USA

Manufacture packed columns that can be used with supplemental oxygen.

Steve Van Gorder 215-683-7933
Fresh-culture Systems
P.O. Box 242
Kutztown, PA 19530
USA

Design of simple mixing chamber for counter-current liquid oxygen injection.

Angelo Barberic 716-691-7474
Greene & Kellogg
290 Creekside Drive
Tonawanda, NY 14150
USA

Manufacturer of Xorbox psa oxygen generator units.

Robert Dimesky 203-224-3500
International Oxygen Corp.
159 John Downey Drive
New Britain, CT 06051
USA

Manufacturer of Nitrox psa oxygen generators

Francisco Sumodjo 602-861-3211
Liquid Air
10010 North 25 th Drive
Suite 100
Phoenix, AR 85021
USA

Application manager responsible for promoting oxygenation systems for aquaculture in the Western United States.

H. D. Brodbeck 914-789-2585
Union Carbide
Linde Division
Market Development
Old Saw Mill River Road
Tarrytown, NY 10591
USA

Market a high efficiency dissolved oxygen system that has been installed at a number of fish facilities.

Ken Robar 303-242-8623
VMG Industries
858 Grand Avenue
Grand Junction, CO 81501
USA

Manufacturer of supplemental oxygen packed columns and AMOX psa oxygen generator units.

Todd Powless 717-677-6181
Zeigler Brothers, Inc.
P.O. Box 95
Gardners, PA 17324
USA

Market the Aquatector oxygen supplementation absorption unit.

SECTION VII

CURRENT RESEARCH IN OXYGEN SUPPLEMENTATION

Individuals active in the research of oxygen supplementation systems are presented in this section. They are sorted by country and personal name.

The following codes are used:

Interests

a Economics of Supplemental Oxygen

b Use of Supplemental Oxygen Systems

c Design/Engineering of Supplemental Oxygen Systems

d Physiological/Biological Effects of Supplemental Oxygen

e Oxygen Toxicity/Gas Bubble Trauma due to High Oxygen Concentrations

CANADA

Larry Fidler 604-879-2869
Dept. of Zoology
University of British Columbia
6270 University Blvd
Vancouver, BC V6T 2A9
CANADA

Interest de

Gas Bubble formation; Gas bubble trauma in fish and cardiovascular response.

Bryan Ludwig 604-387-9682
Fisheries Branch
Ministry of Environment & Parks
Parliament Buildings
Victoria, BC V8V 1X5
CANADA

Interest bc

Application of supplemental oxygen systems

Don MacKinlay 604-666-3520
SEP
555 West Hastings Street
Vancouver, BC V6B 5G3
CANADA

Interest . abcde

Effects of high concentration of oxygen on mortality, growth, and physiology of salmon and trout

Jack Mathias 204-983-5155
Fisheries and Oceans
Freshwater Institute
501 University Cresent
Winnipeg, Man. R3T 2N6
CANADA

Interest abcde

Biological effects of supplemental oxygen on salmonids

USA

Gary Boersen 517-373-1280
Fisheries Division
Michigan D.N.R.
P.O. Box 30028
Lansing, MI 48909

Interest bc

Design of supplemental oxygen systems

Gerald R. Bouck
Division of Fish and Wildlife (PJS)
Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208-3621

Interest abcde

Currently funding a hathery-scale demonstration project on spring chinook salmon regarding supplemental oxygen and rearing density.

Howard Brodbeck 914-789-2585
Linde Division
Market Development
Union Carbide Corporation
Old Saw Mill River Road
Tarrytown, NY 10591
U S A

Interest c

Application of supplemental oxygen systems

John Colt 916-678-5126
Fish Factory
P.O. Box 5000
Davis, CA 95617
USA

Interest abcde

Design of supplemental oxygen systems

William Dwyer 406-587-9265
Fish Technology Center
4050 Bridger Canyon Road
Bozeman, MT 59715
USA

Interest cde

Oxygen injection in high and low pressure systems

Richard Ewing
Oregon Department of Fish and Wildlife
850 S.W. 15th Street
Corvallis, OR 97333

Interest abcde

Conducting studies of the effects of rearing density and supplemental oxygen on the culture of spring chinook salmon.

Joseph Fuss 312-855-5686
Harza Engineering Company
150 S. Wacker
Chicago, IL 60606-4288
USA

Interest abc

Design of on-line monitoring equipment

Donald Garling 517-355-7493
Michigan State University
Dept. Fish. & Wildl.
East Lansing, MI 48864
USA

Interest abde

Effects of gas supersaturation on salmonids

James Geiger 304-725-8461
U.S. and Wildlife Service
Box 700
Kearneyville, WV 25430
USA

Interest cde

Effects of oxygen injection upon swimbladder inflation, survival, and growth of larval striped bass

Todd Hanna 906-632-FISH
Lake Superior State University
102 Union St. (Salmon Run)
Sault Ste. Marie, MI 49783
USA

Interest abcde

Effects of hyperoxic conditions on hatchery reared rainbow trout

Terry Kayes 608-263-1242
UM Aquaculture Program
Babcock Hall
University of Wisconsin
Madison, WI 53706
USA

Interest abcde

Assessment of low-level gas supersaturation and oxygen supplementation as stressors in lake and rainbow trout

William Krise 717-724-3322
U.S. Fish & Wildlife Service
R. D. #4, Box 63
Wellsboro, PA 16901
USA

Interest de

Biological effects of gas supersaturation and oxygen supplementation

Lief Marking 608-783-6451
U.S. Fish and Wildlife Service
Box 818
Lacrosse, WI 54602
USA

Interest abcde

Gas supersaturation problems in fisheries and aquaculture

James Meade 717-724-3322
U.S. Fish & Wildlife Service
R. D. #4, Box 63
Wellsboro, PA 16901
USA

Interest cde

Biological effects of gas supersaturation and oxygen supplementation; design of oxygen systems

Nick Parker 205-683-6175
Southeastern Fish Cultural Research Lab
U.S. Fish and Wildlife Service
Route 3, Box 86
Marion, AL 36756
USA

Interest abcde

Growth of striped bass at various levels of oxygen and the influence of oxygen saturation and total gas pressure on swimbladder inflation

Kris Orwicz 916-678-5126
Aquatic Biotics
1245 Cunningham Dr.
Dixon, CA 95620

Interest abcde

Development of bio-criteria for supplemental oxygen systems

George Seeley 518-457-5430
Dept of Conservation
50 Wolf Road, Rm 518
Albany, NY 12233
USA

Interest

Design of gas monitoring equipment

Charlie Smith 406-587-9265
Fish Technology Center
4050 Bridger Canyon Rd
Bozeman, MT 59715
USA

Interest abcde

Design of low and high pressure oxygen absorber units. The biological effects of oxygen supersaturation on fish.

Robert Summer-felt 515-294-6107
Dept of Animal Ecology
Iowa State University
Ames, Iowa 50011
USA

Interest bde

The use of supersaturated oxygen to enhance gas bladder inflation rates of walleye

Baraby Watten 205-821-1904
Auburn University
1105 Rustic Ridge Rd.
Auburn, AL 36830
USA

Interest bc

Design of supplemental oxygen absorption equipment

Harry Westers 517-373-1280
Fisheries Division
Michigan D.N.R.
P.O. Box 30028
Lansing, MI 48909

Interest abcde

Design of supplemental oxygen systems

GBouck:pat:10/07/88 (VS6-PJSR-5113N)